Full-Scale FEED Study For a 816 MWe Capture Plant at the Prairie State Generating Company Using Mitsubishi Heavy Industries of America Technology

Kevin C OBrien, PhD
Director, Illinois Sustainable Technology Center
Director, Illinois State Water Survey
Prairie Research Institute
University of Illinois at Urbana-Champaign

DOE/NETL Project Closeout Meeting
Pittsburgh, PA / June 14, 2022

Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NETL NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Agenda

- Introduction, Overview & Summary of Results (UIUC)
- Results of Studies and Investigations
  - UIUC Lead Investigations (UIUC)
  - S&L/Kiewit Lead Investigations (Kiewit)
  - MHI Lead Investigations (MHI)
  - Constructability Review (Kiewit)
  - Outline of Resulting Plot Plan (Kiewit)
- ISBL Detailed Design Results (MHI)
- OSBL Detailed Design Results (Kiewit)
- Overall Plant Performance (Kiewit)
- Overall Plant Cost (Kiewit)
- Closing Discussions (PSGC)

Cooperative Agreement No. DE-FE0031841

PROJECT OVERVIEW

Funding: $17,509,676

DOE: $14,004,676

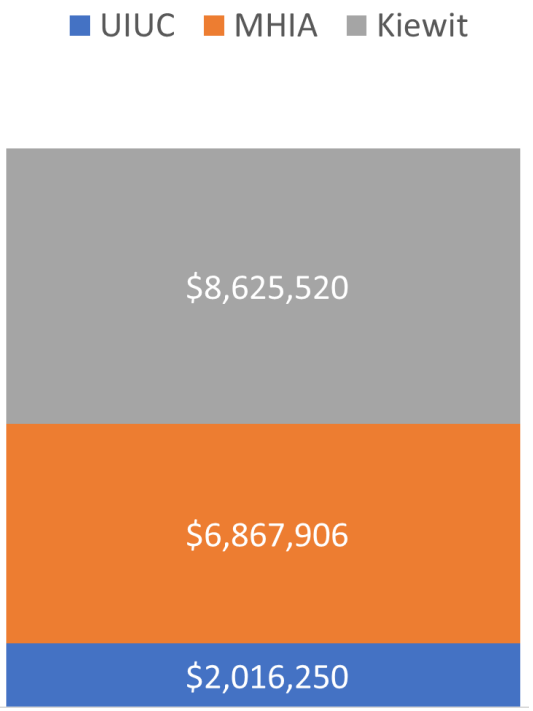
20% Cost Share: $3,505,000 (PSGC)

Work Period: 1 Jan 2020 – 31 Dec 2021

Incurred Expenses (1 April 2022)

DOE: $13,349,525

Cost Share: $3,454,337

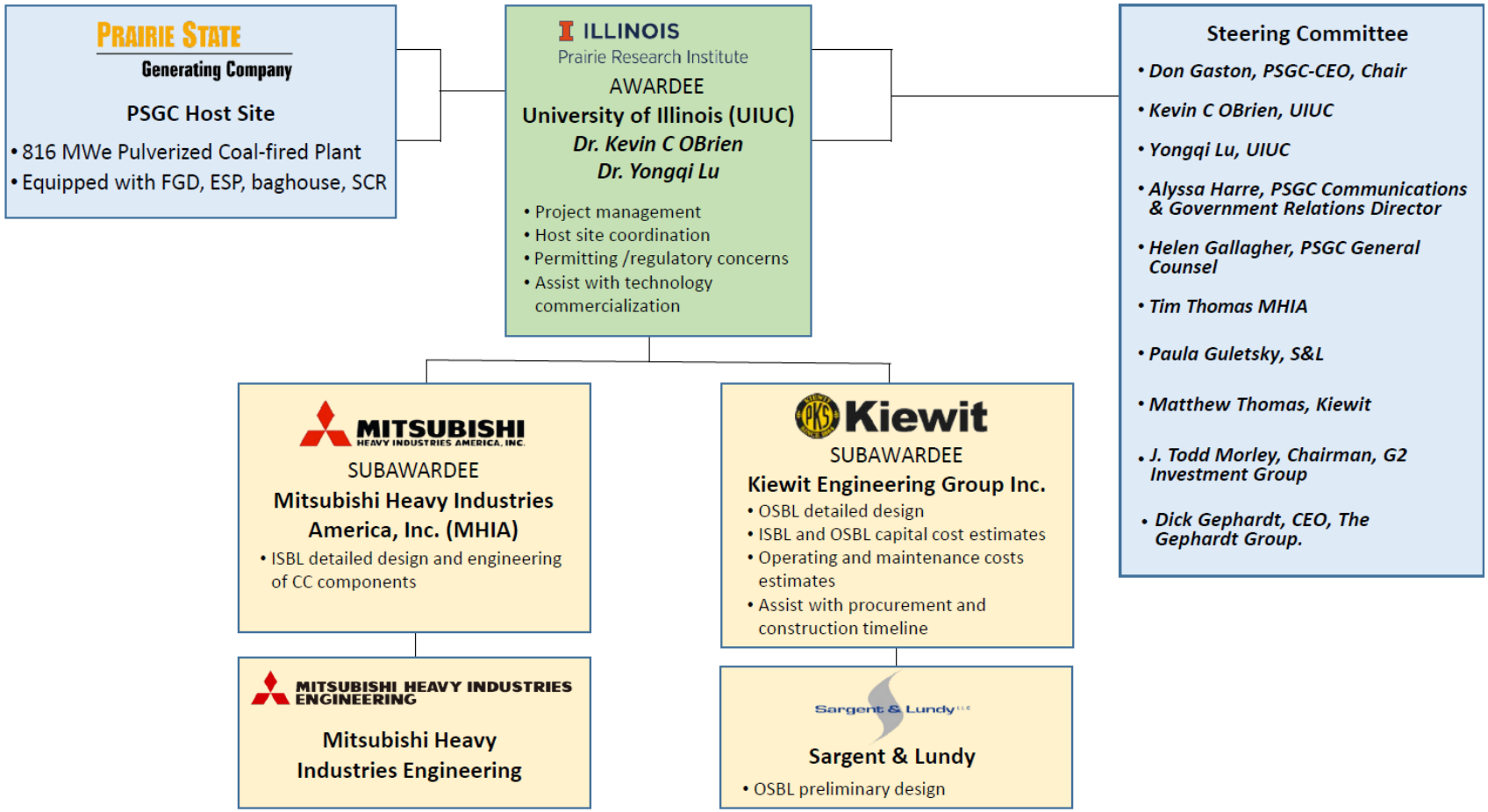


PROJECT OBJECTIVES:

Overall: Perform a Front-End Engineering Design (FEED) study for the retrofit of the Prairie State Generation Company's (PSGC) coal-fired power plant with post-combustion carbon capture. The FEED study will outline the use of Mitsubishi Heavy Industries' (MHI) Advanced KM CDR Process™ to retrofit one of PSGC's two generating units (approximately 816 MWe). The FEED study will enable PSGC to move forward with actual build/operate in future work.

Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY

Project Team Management Structure

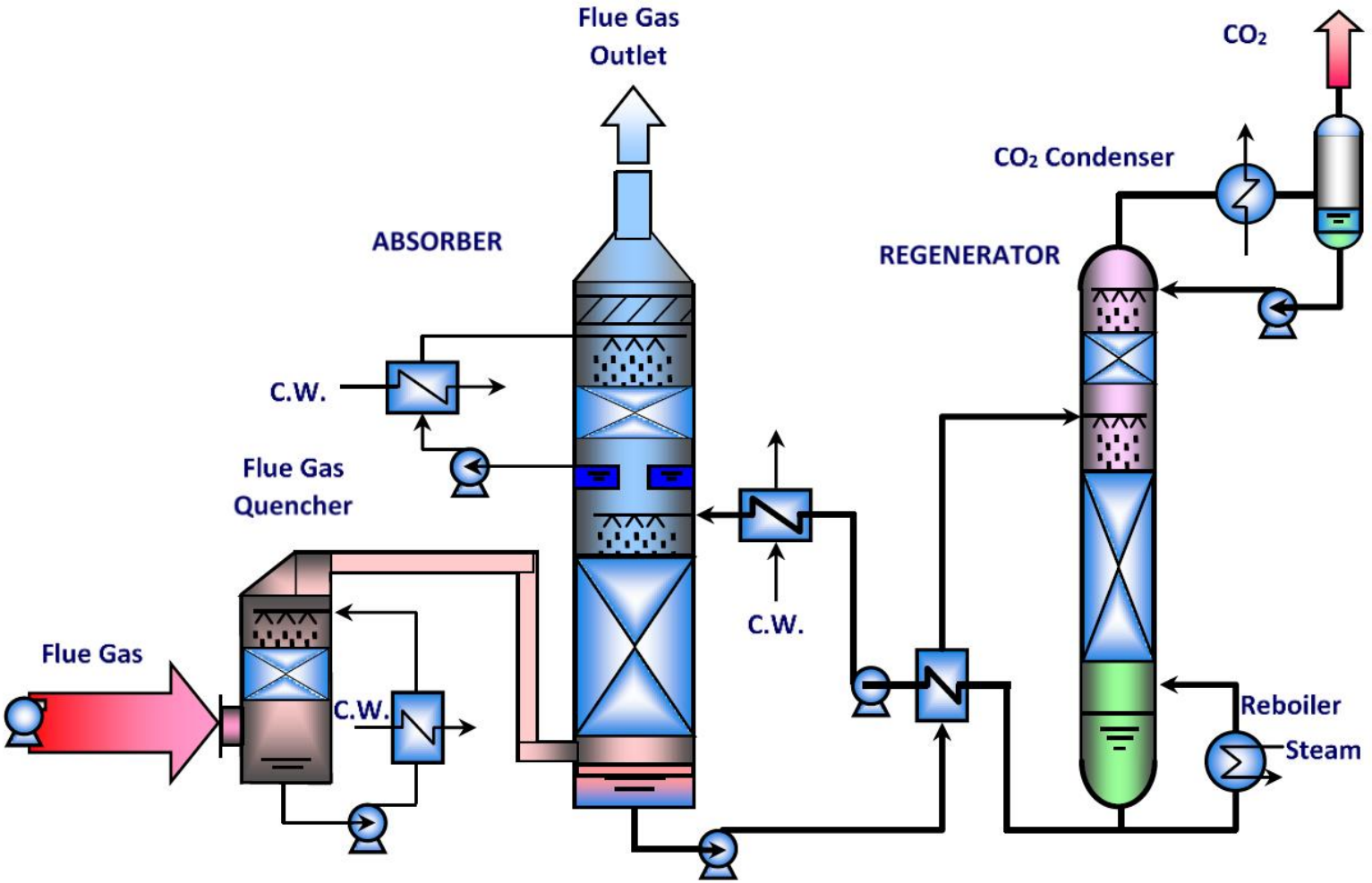


FRONT-END ENGINEERING DESIGN STUDIES FOR CARBON CAPTURE SYSTEMS ON COAL AND NATURAL GAS POWER PLANTS

THE TECHNOLOGY

Kiewit | MITSUBISHI HEAVY INDUSTRIES AMERICA | ILLINOIS Prairie Research Institute | PRAIRIE STATE Generating Company | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY | U.S. DEPARTMENT OF ENERGY

Mitsubishi Heavy Industries' (MHI) Advanced KM CDR Process™



Kiewit · MITSUBISHI HEAVY INDUSTRIES AMERICA · ILLINOIS Prairie Research Institute · PRAIRIE STATE Generating Company · NETL National Energy Technology Laboratory · U.S. Department of Energy

KS-21™ Solvent

- MHI has been able to conclude that there are likely operating cost benefits for using KS-21™ instead of KS-1™
- KS-21™ has several advantageous properties such as lower volatility and greater stability which result in:
  - Lower amine emissions
  - Lower solvent make-up
  - Lower compression energy

FRONT-END ENGINEERING DESIGN STUDIES FOR CARBON CAPTURE SYSTEMS ON COAL AND NATURAL GAS POWER PLANTS

THE PROJECT

Kiewit

MITSUBISHI HEAVY INDUSTRIES AMERICA

ILLINOIS Prairie Research Institute

PRAIRIE STATE Generating Company

NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

Project Tasks

Task #	Task
1.0	Project Management and Planning
2.0	Front-End Engineering Design (FEED) Study
2.1	Design Basis
2.2	Preliminary Engineering
2.3	ISBL Detailed Engineering
2.4	OSBL Detailed Engineering
2.5	Studies and Investigations
2.6	Cost Assessment
3.0	Regulatory and Permitting at Host Site
4.0	Final FEED Study Package

Kiewit · Mitsubishi Heavy Industries America · Illinois Prairie Research Institute · Prairie State Generating Company · National Energy Technology Laboratory · U.S. Department of Energy

Project Milestones

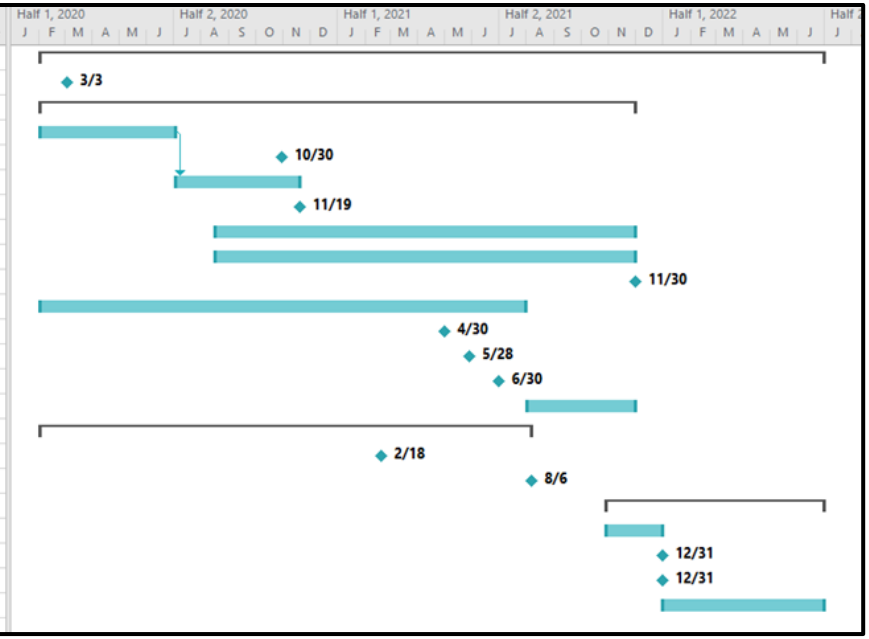
Task #	Deliverable Title	Due Date
1.0	Project Management Plan Update	~~3/3/2020~~
2.0	Design Basis Document Complete	~~10/30/20~~
2.0	Report on Utility Requirements	~~11/19/20~~
3.0	Preliminary Regulatory and Permitting Pathway	~~2/18/21~~
2.0	HAZOP Review	~~4/30/21~~
2.0	Impact on Kaskaskia Watershed Document Complete	~~5/28/21~~
2.0	Constructability Review Complete	~~6/30/21~~
3.0	Regulatory and Permitting Analysis Complete	~~8/6/2021~~
2.0	Detailed Engineering Document Complete	~~11/30/21~~
4.0	Final Report Submitted	~~12/31/21~~
4.0	FEED Study Package Complete	~~12/31/21~~

- All quarterly advisory board meetings were held as planned

Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY

Project Timeline

Task Name	Start	Finish	Manhours	Budget
Task 1.0 Project Management and Planning	**Mon 2/3/20**	**Thu 6/30/22**	**4,413**	**$257,036**
a. Project Management Plan (PMP) Submitted	Tue 3/3/20	Tue 3/3/20		
Task 2.0 Front-End Engineering Design (FEED) Study	**Mon 2/3/20**	**Tue 11/30/21**	**134,89**	**$14,930,093**
Subtask 2.1 Design Basis	Mon 2/3/20	Thu 7/2/20		
b. Design Basis Document Complete	Fri 10/30/20	Fri 10/30/20		
Subtask 2.2 Preliminary Engineering	Fri 7/3/20	Thu 11/19/20		
c. Report on Utility Requirements	Thu 11/19/20	Thu 11/19/20		
Subtask 2.3 ISBL Detailed Engineering	Mon 8/17/20	Tue 11/30/21		
Subtask 2.4 OSBL Detailed Engineering	Mon 8/17/20	Tue 11/30/21		
d. Detailed Engineering Document Complete	Tue 11/30/21	Tue 11/30/21		
Subtask 2.5 Studies and Investigations	Mon 2/3/20	Fri 7/30/21		
e. HAZOP Review	Fri 4/30/21	Fri 4/30/21		
f. Impact on Kaskaskia Watershed Document Complete	Fri 5/28/21	Fri 5/28/21		
g. Constructability Review Complete	Wed 6/30/21	Wed 6/30/21		
Subtask 2.6 Cost Assessment	Mon 8/2/21	Tue 11/30/21		
Task 3.0 Regulatory and Permitting at Host Site	**Mon 2/3/20**	**Fri 8/6/21**	**6,861**	**$309,537**
h. Preliminary Regulatory and Permitting Pathway	Thu 2/18/21	Thu 2/18/21		
i. Regulatory and Permitting Analysis Complete	Fri 8/6/21	Fri 8/6/21		
Task 4.0 Final FEED Study Package	**Fri 10/29/21**	**Thu 6/30/22**	**100**	**$4,768**
Develop Final Report	Fri 10/29/21	Fri 12/31/21		
j. FEED Study Package Submitted to PSGC	Fri 12/31/21	Fri 12/31/21		
k. Final Report Submitted to DOE	Fri 12/31/21	Fri 12/31/21		
Respond to DOE Review	Sat 1/1/22	Thu 6/30/22		



- Project was completed within budget and on-time despite challenges due to COVID-19 pandemic

Summary of Results

- 8,462,000 ston annually of CO_2
- Project Capital Cost Estimate (+/- 15%)
  - $2,044,465,000
- Cost of Capture
  - $43.42/metric tonne of CO_2

Studies and Investigations

- UIUC Lead Studies
    i. Water Supply Study
    ii. Air Permitting Pathway
    iii. Water Permitting Pathway

Water Supply Study

- Draw raw water from the Kaskaskia River
  - 14 million gallons per day (mgd)
- Build a storage pond for drought conditions
  - Water is available for use during wet (normal) conditions
  - No allocation remaining, unable to draw water during drought conditions
  - Store 26 days of water (25-year drought)

Regulatory and Permitting at Host Site

Air Permitting Pathway

Carbon Capture Plant as a Separate Source with Only Emissions Created by the Carbon Capture Plant Subject to Permitting

<u>Advantages</u>

- Carbon capture plant will have own air permit with no overlapping requirements
- Only address emissions generated by carbon capture plant

<u>Disadvantages</u>

- IEPA may impose new requirements to PSGC existing permits
  - Believed to be unlikely given that the monitoring of emission could be implemented upstream of the divergence of the flue gas to the carbon capture plant

Regulatory and Permitting cont.

Water Permitting Pathway

Raw Makeup Water

- File a request to Illinois Department of Natural Resources (IDNR) to use public water from the Kaskaskia River
  - New construction activities outside waterway - only a request to use public water is needed to be filed to IDNR.
  - New construction activities inside waterway - a joint permit application to IDNR, Illinois Environmental Protection Agency (IEPA), and USACE will be required
- Limiting conditions based on draw needs during draught conditions
  - May be able to gain allocation rights if other users shutdown operations

Regulatory and Permitting cont.

Water Permitting Pathway

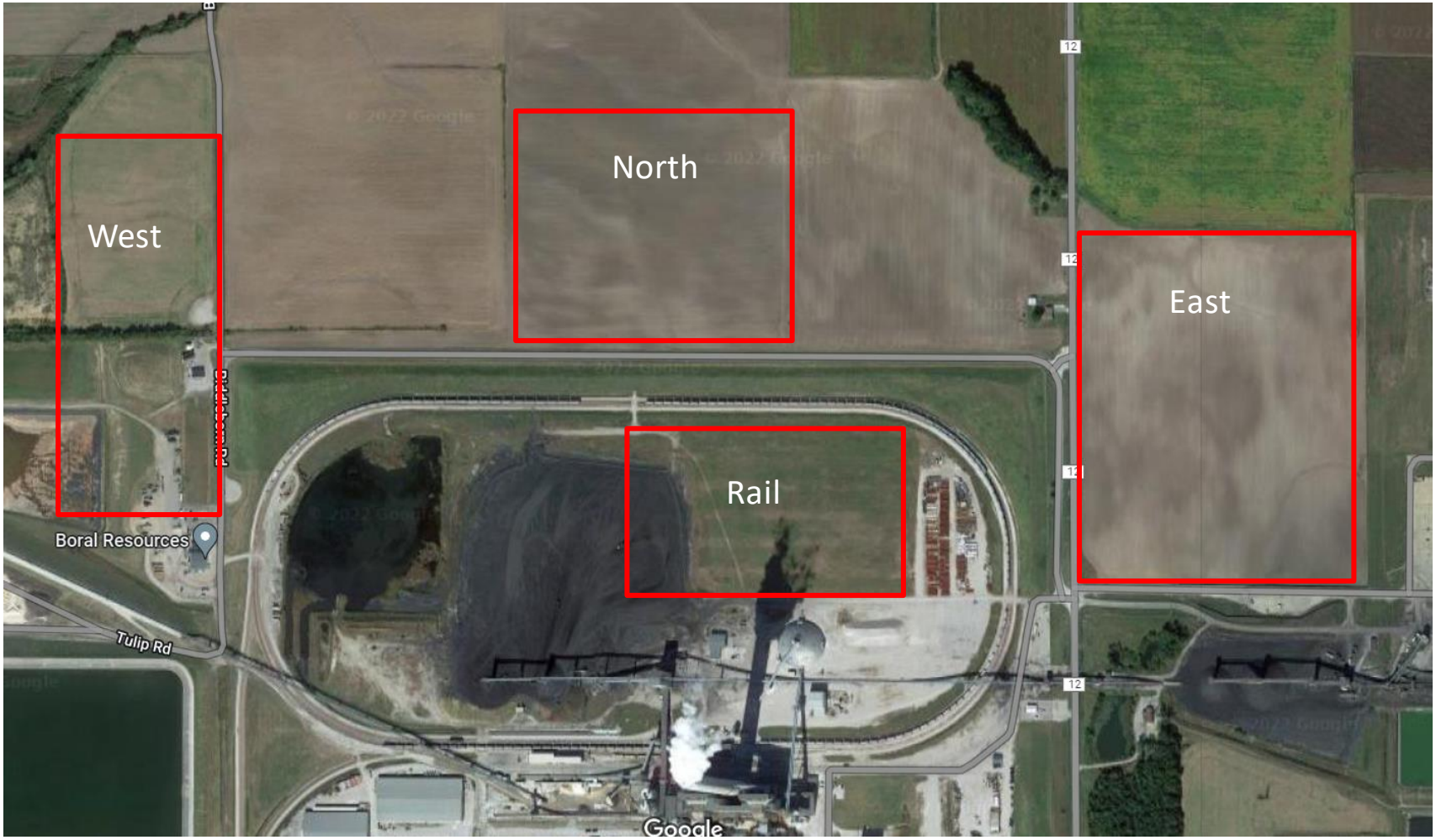
Wastewater

- Discharging treated cooling tower blowdown into the Kaskaskia River will require a National Pollutant Discharge Elimination System (NPDES) permit
- Removal of trace metals to the concentrations indicated in 35 Illinois Administrative Code (IAC) 302
  - No mixing zone at the new cooling tower blowdown discharge to the Kaskaskia River will be allowed.
- NPDES discharge limitations for total suspended solids (TSS) expected to be like existing PSGC cooling tower blowdown

Studies and Investigations

- Kiewit and S&L Lead Studies
    i. Site Selection
    ii. Ammonia Scrubber Study
    iii. Cooling Sourcing Study
    iv. Water and Wastewater Treatment Study
    v. Steam and Electric Sourcing Study
    vi. Flue Gas Tie-In Study

Site Selection



Kiewit
MITSUBISHI HEAVY INDUSTRIES AMERICA
ILLINOIS Prairie Research Institute
PRAIRIE STATE Generating Company
NATIONAL ENERGY TECHNOLOGY LABORATORY
U.S. DEPARTMENT OF ENERGY

Site Selection

West and North Locations

- Ruled out after consulting with Mine Engineer
- Concerns of causing structural issues
- Use of either site would require extensive mine remediation

Rail Loop

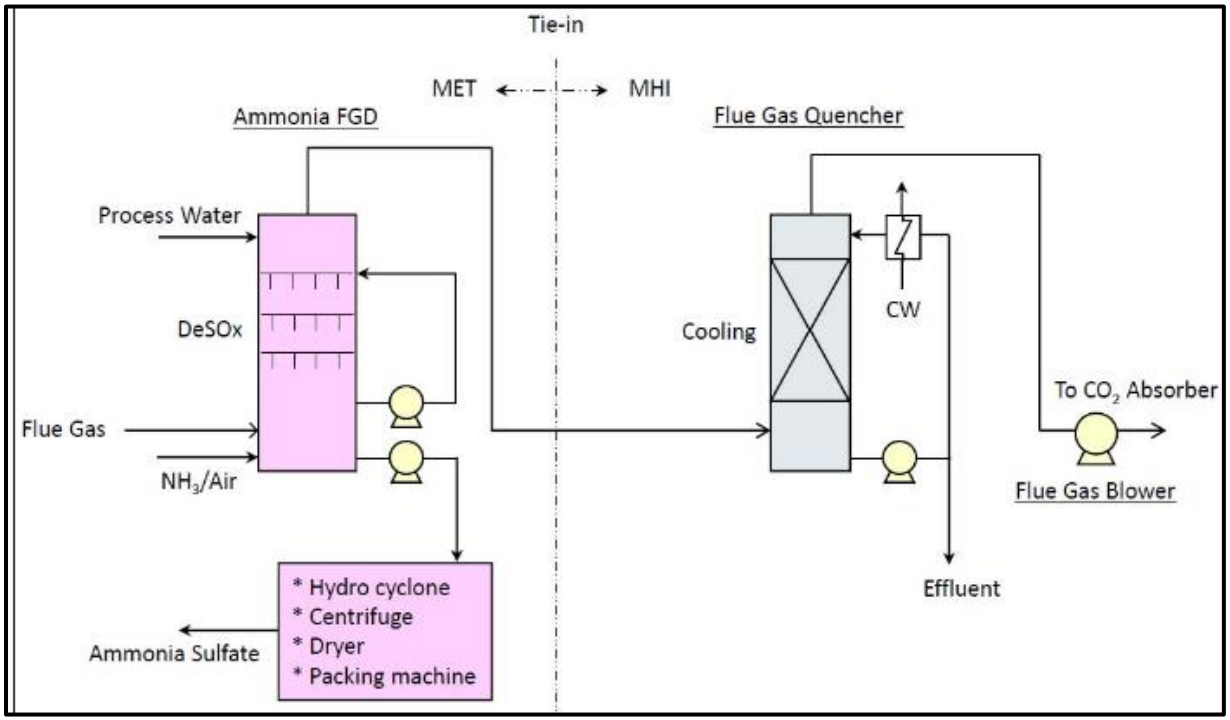
- Tight location, Requires Modifications to Rail Loop, Prevents future power block use of this area
- Shortest Duct Length
- Extended Impact to Power Plant Operations during construction

East Location SELECTED

- Requires longer Ducting – optimized with diagonal path
- More land availability
- Clean separation of company assets with physical barriers

Ammonia Scrubber Study

- Evaluated: Ammonia Scrubber and separate Quencher
  - Additional material handling system required to produce Ammonia sulfate



Ammonia Scrubber Study

- Results:
  - Table Below
  - Payback Period >25 years
- Conclusion:
  - Insufficient economic benefit to justify added complexity
  - Integrated Quencher (Base) Selected

	Base	Ammonia Scrubber
Capital Cost	Base	103,954,000
First Year Operating Costs, $/yr	2,780,000	(5,958,000)

Cooling Sourcing Study

- Evaluated best-fit cooling technology for project
- Evaluated Technologies
  - Mechanical Draft Cooling Tower(MDCT)
  - Hybrid MDCT/Air-Cooled Fin Fan Heat Exchanger(FFHE)
  - Wet Surface Air Cooler(WSAC)

Description	Cost	Recommended	Notes
MDCT	$14MM	Yes	Lowest Cost.
Hybrid MDCT/FFHE	-	No	Not technically feasible. Hot water temperature is low relative to high ambient, no benefit.
WSAC	$36MM	No	High cost. 50% water savings.

Water and Wastewater Treatment

Evaluation of available treatment options, maximize re-use, and minimize overall cost.

- Water Sources:
  - Kaskaskia River
  - Quencher Blowdown
- Requirements Driving Water Treatment Equipment:
  - Cooling Tower Makeup
  - Steam Generation System Makeup
  - Carbon Capture system Makeup
  - NPDES Permit Discharge Requirements

Illinois Administrative Code(IAC) IAC 302 limits indicative of the most stringent limits that may be applied. Determined to be appropriate for this study.

Parameter	IAC 302 Limit	Parameter	IAC 302 Limit
Total Suspended Solids (TSS), ppm	15	Cadmium, ppm	0.002
Arsenic, ppm	0.19	Chromium, ppm	0.011
Barium, ppm	5	Copper, ppm	0.02
Iron, ppm	1	Manganese, ppm	3.36
Mercury, ppm	0.000012	Selenium, ppm	1

Water and Wastewater Treatment

Results:

- Water Sources:
  - Water Inputs:
    - 8,300 gpm makeup water required from Kakaskia River
    - 2,300 gpm Caustic Flue Gas Condensate Wastewater
  - Discharge:
    - 3,450 gpm to New Kakaskia River Outfall
- Treatment Selected:
  - Raw Water Treatment(CT Makeup): Hardness and TSS removal by lime softening, clarification, and multi-media filtration
  - Demineralized Water(Steam and CC Makeup): TDS Removal by RO
  - Wastewater Treatment: Trace Metal Removal by sulfide precipitation

Steam and Electric Sourcing Study

Evaluation of available options for providing the facility with steam and electricity.

- Option 1: Package boilers, power from grid
- Option 2: Co-generation facility employing gas-fired CTs
- Option 3: Co-generation with package boilers and a backpressure steam turbine for power generation.

Option 2 was broken down into four sub-options:

- Option 2a – 1x SGT6-800 CT, package boilers
- Option 2b – 1x SGT6-2000E CT + HRSG, package boilers
- Option 2c – 2xGE7F.04 CTs + HRSGs, package boiler
- Option 2d – 3x3 Combined Cycle SGT6-2000E CTs

Steam integration with host plant was initially explored, but this option was eliminated from further evaluation as host plant could not accept a derate.

Steam and Electric Sourcing Study

- Option 2, Challenges with Co-generation Configurations
  - Power generated and steam output do not align well with capture facility needs. All configurations require one or both of (a) auxiliary boilers to supplement steam (b) sale of excess power to market.
  - PSGC did not want to generate significant additional power that would need to be sold
  - The large quantity of low-quality steam, as required for the capture plant, would require a specialized HRSG design which would need to be developed.

Results below:

- Option 1 Selected, Lowest Cost

Option	Description:	Notes:	Evaluated Cost*	Evaluated Cost of Capture*	Selected
1	Package Boilers	Lowest CAPEX	$496MM	$23.91	X
3	Package Boilers with BP Steam Turbine	Higher Capex, Lowest Cost of Capture	$570MM ($74MM)	$23.59 $0.32	

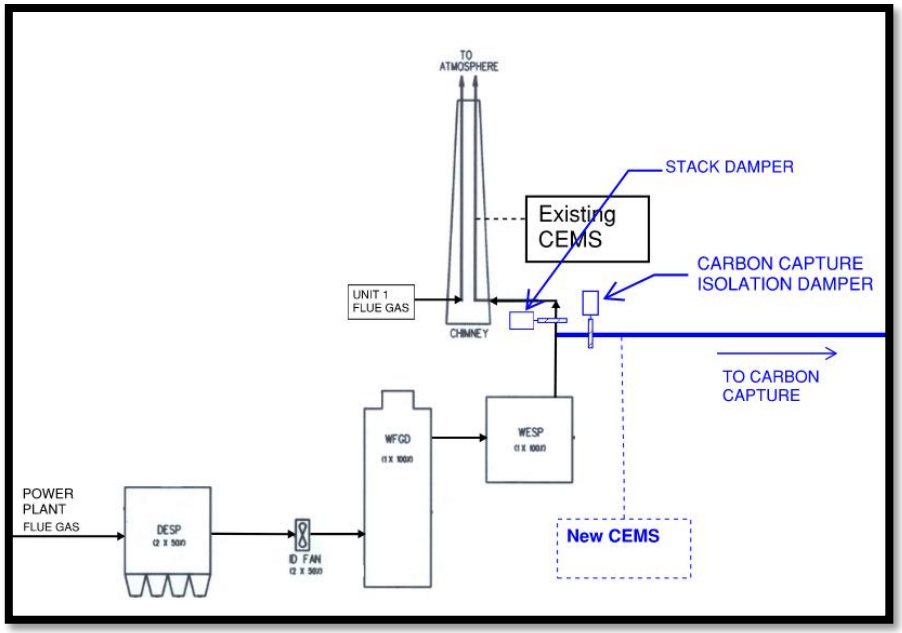
*Evaluated Cost and Cost of Capture do not include ISBL costs.

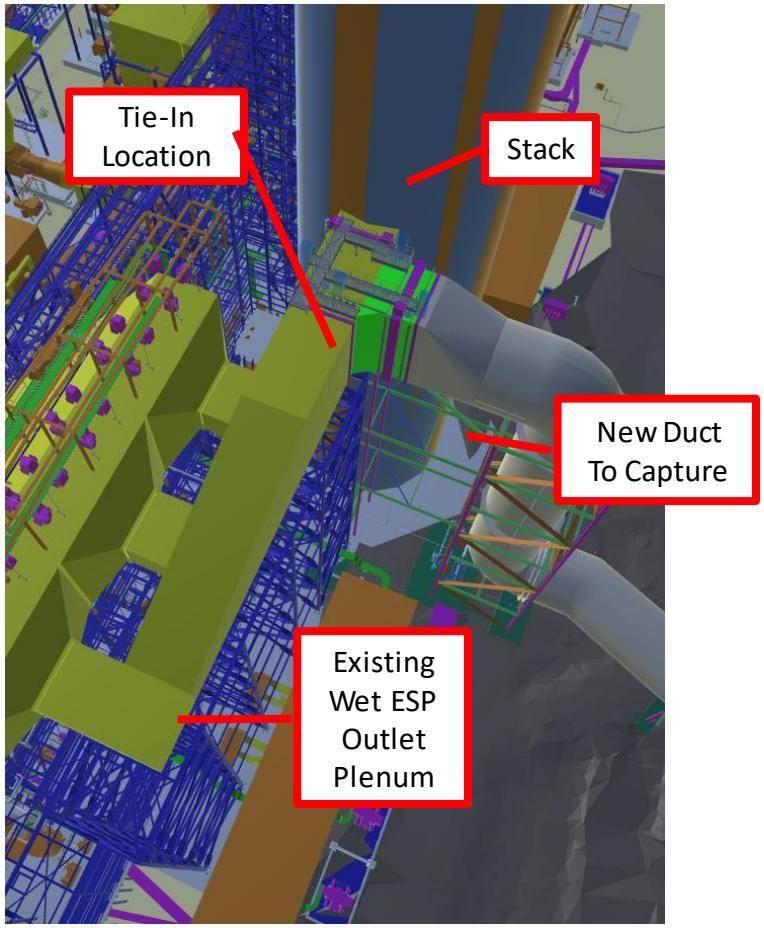
Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NETL NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY

Flue Gas Tie-In Study

Purpose:

1. Calculate pressure drop for use sizing MHI flue gas fans
2. Provide preliminary tie-in/duct design
3. Identify opportunities and risks for further investigation





Kiewit · MITSUBISHI HEAVY INDUSTRIES AMERICA · ILLINOIS Prairie Research Institute · PRAIRIE STATE Generating Company · NETL NATIONAL ENERGY TECHNOLOGY LABORATORY · U.S. DEPARTMENT OF ENERGY

Flue Gas Tie-In Study

- Pressure Drop Results
  - Train 1&3: 9.05 inWC
  - Train 2&4: 8.04 inWC
  - From Wet ESP inlet to Quencher Inlet (ISBL Scope)
- Flow Modifications to Existing Wet ESP Outlet Plenum(right)
- Opportunities
  - Optimization of Vane Placement
- Risk Mitigation, Example
  - Mixing at Quencher Inlet; control instrumentation
  - Allowance for study during project
  - Agreed Plan to reconfigure instrumentation if proper mixing cannot be achieved

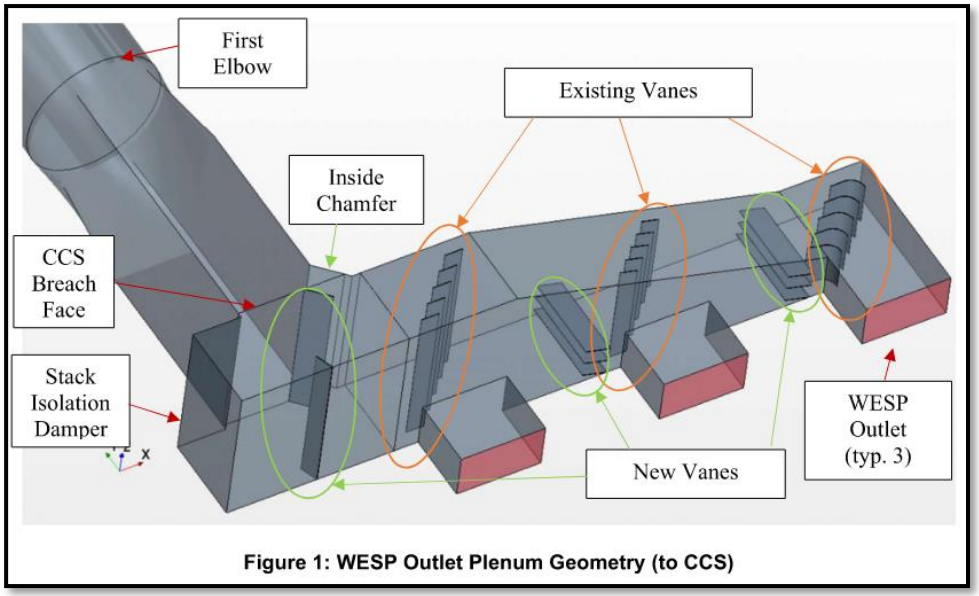


Figure 1: WESP Outlet Plenum Geometry (to CCS)

Studies and Investigations

- MHI Studies
  i. Flue Gas Testing
  ii. Transportation Study
  iii. Hazard and Operability (HAZOP) Review

Flue Gas Testing

- Flue gas testing was conducted in 2020 and design conditions of trace components were determined according to its results.
- Design conditions of main components were determined based on the CEMS trend data.

Transportation Study

- Inland Transportation Studies Made

Dock	Location	Distance to Site	Selected
Ingram Dock	Mississippi River	50.0 miles	-
KRPD Dock	Kaskaskia River	19.0 miles	X
Evansville Dock	Kaskaskia River	36.4 miles	-

- Module Size decided

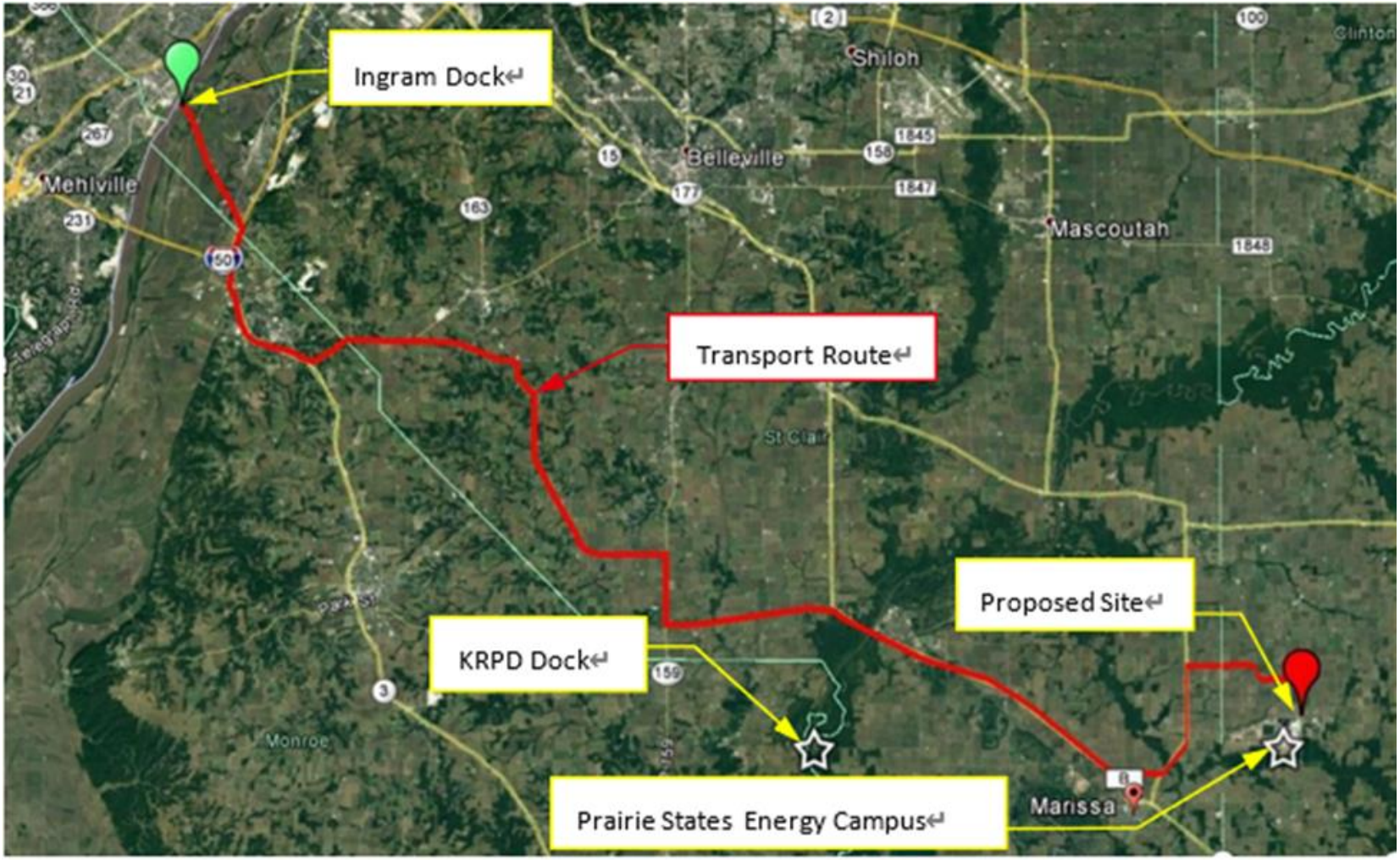
	Dimension	Restriction
Length	80’-0”	River Barge Size
Width	50’-0”	River Barge Size
Height	29’-6”	River Bridge Head Clearance

- Challenges

Need to modify Power(44)/Utility Lines prior to the Module transportation which will take 9 months Engineering and 18 months modification work

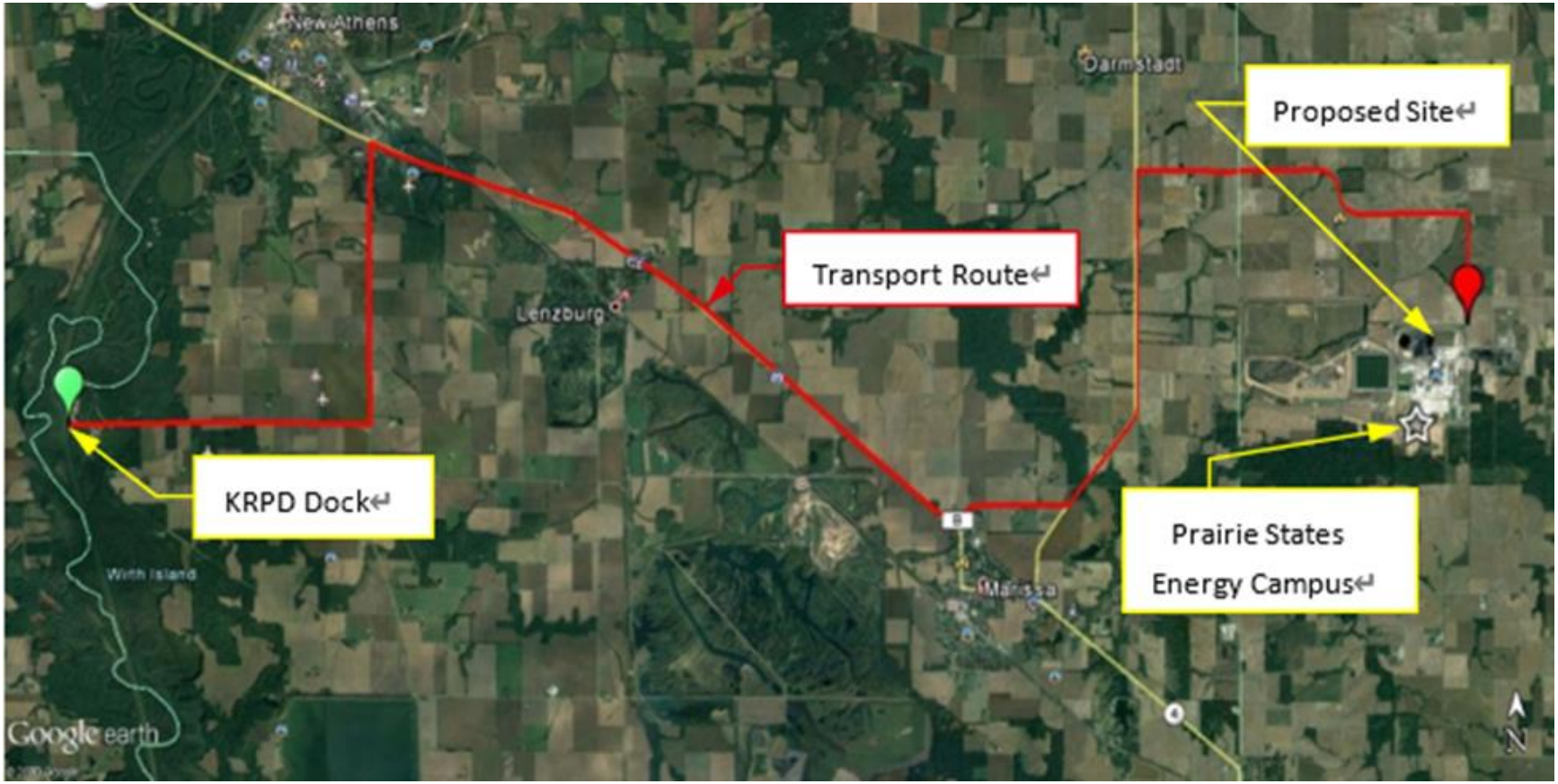
Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY

Transportation Study



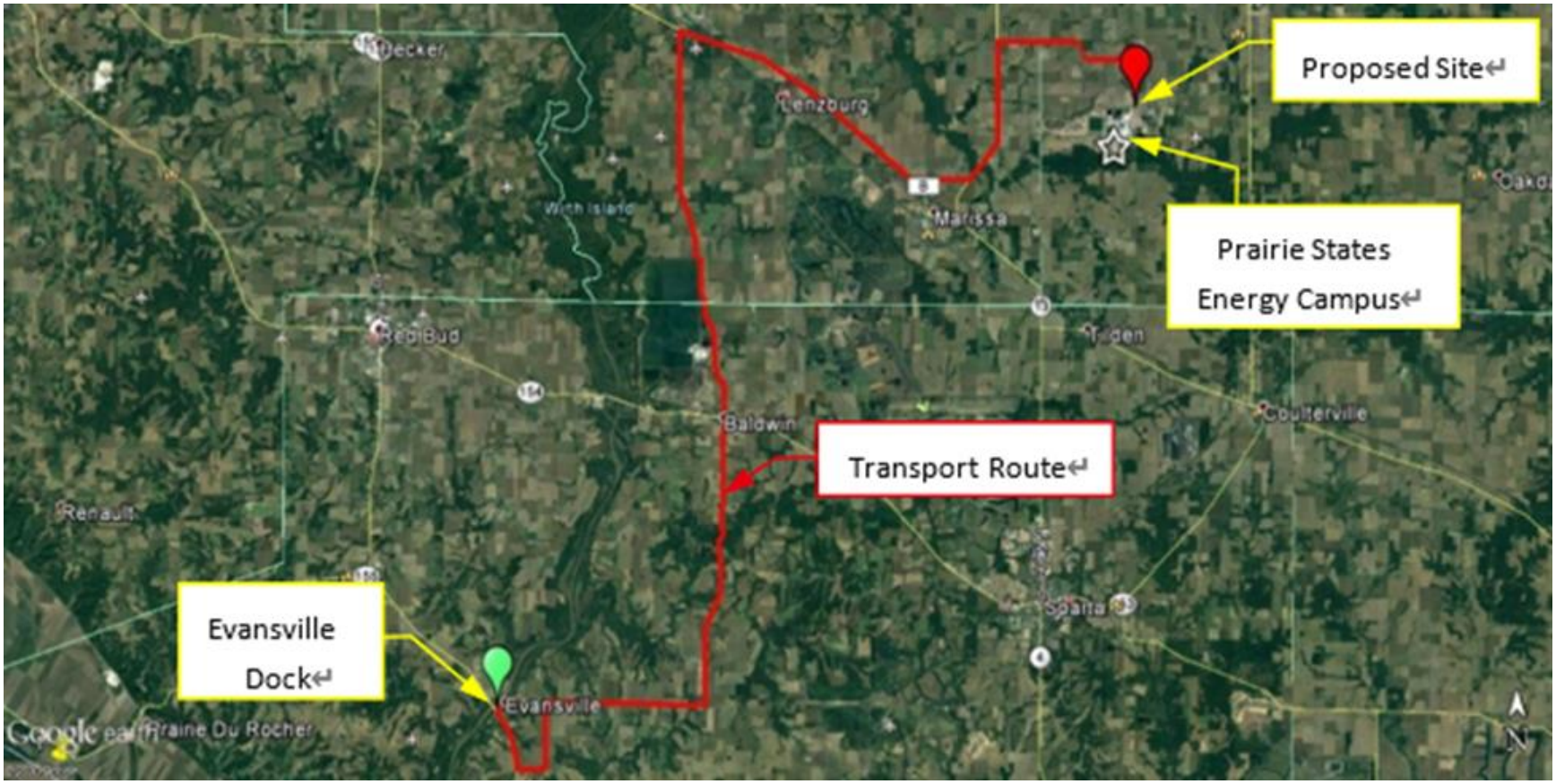
Kiewit · Mitsubishi Heavy Industries America · Illinois Prairie Research Institute · Prairie State Generating Company · National Energy Technology Laboratory · U.S. Department of Energy

Transportation Study



Kiewit · MITSUBISHI HEAVY INDUSTRIES AMERICA · ILLINOIS Prairie Research Institute · PRAIRIE STATE Generating Company · NETL NATIONAL ENERGY TECHNOLOGY LABORATORY · U.S. DEPARTMENT OF ENERGY

Transportation Study



Hazard and Operability (HAZOP) Review

- An in-depth examination of the ISBL section to identify and evaluate any process or equipment risks.
  - 0 recommendations address “A” - Critical risk items
  - 0 recommendations address “B” - Serious risk items
  - 13 recommendations address “C” - Moderate risk items
  - 0 recommendations address “D” - Minor risk items
  - 0 recommendations address “E” - Negligible risk items
  - 5 recommendations address “O” - Operating issue items

Constructability Review

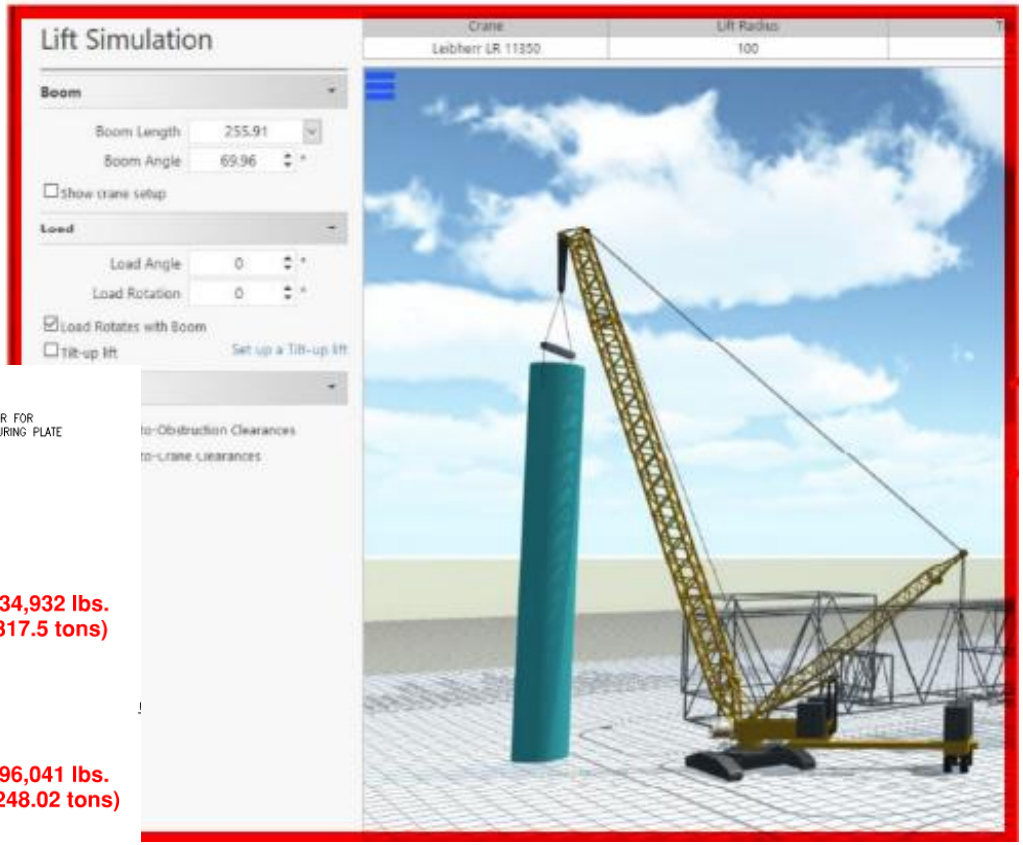
- Kiewit

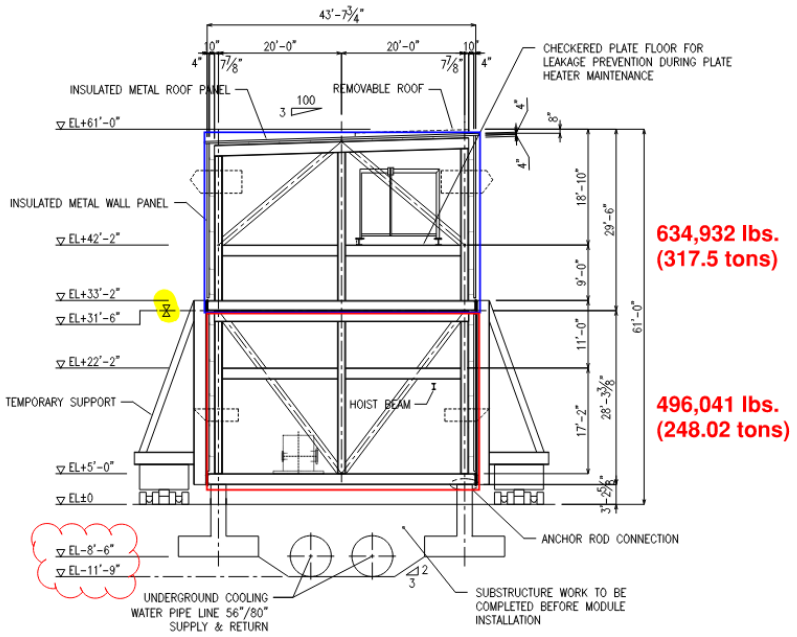
Constructability Review

- Systematic process that provides a framework for improving the project's buildability by identifying obstacles during the pre-construction phase to reduce and prevent errors, delays, and cost overruns.
- Evaluated and identified construction access, lay-down areas, lift plans, and sequencing of construction work

Constructability Review

- Mirrored arrangement limits movement of heavy lift crane
- Modules dressed and stacked directly north of plot



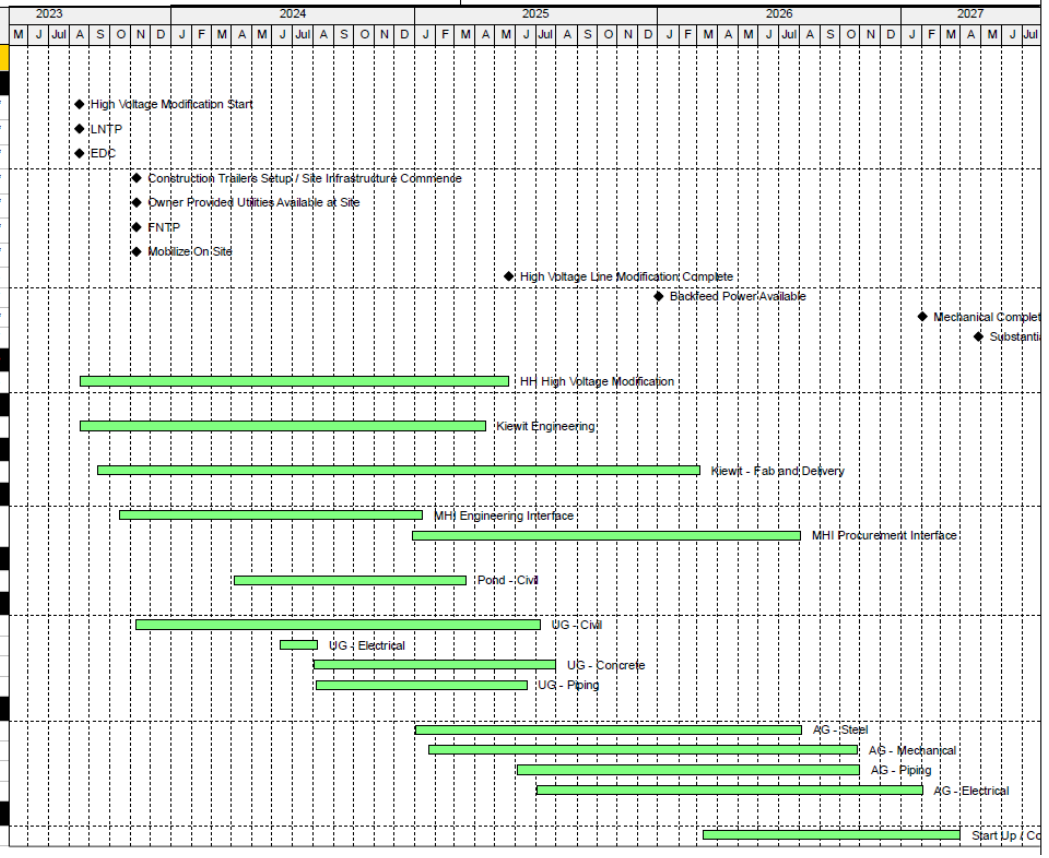


Constructability Review – Project Schedule

Kiewit

Prairie State - L1

Activity Name	Original Duration	Start	Finish
Prairie State CCS EPC	939	16-Aug-23	27-Apr-27
01. Project Milestones	939	16-Aug-23	27-Apr-27
High Voltage Modification Start	0		16-Aug-23*
LNTP	0		16-Aug-23*
EDC	0		16-Aug-23*
Construction Trailers Setup / Site Infrastructure Commence	0		09-Nov-23*
Owner Provided Utilities Available at Site	0		09-Nov-23*
FNTP	0		09-Nov-23*
Mobilize On Site	0		09-Nov-23*
High Voltage Line Modification Complete	0		21-May-25
Backfeed Power Available	0		02-Jan-26*
Mechanical Completion	0		02-Feb-27*
Substantial Completion	0		27-Apr-27*
02. HH High Voltage Modification	443	17-Aug-23	21-May-25
HH High Voltage Modification	443	17-Aug-23	21-May-25
03. Engineering	420	17-Aug-23	17-Apr-25
Kiewit Engineering	420	17-Aug-23	17-Apr-25
04. Procurement	623	12-Sep-23	04-Mar-26
Kiewit - Fab and Delivery	623	12-Sep-23	04-Mar-26
05. MHI Interface	706	15-Oct-23	02-Aug-26
MHI Engineering Interface	310	15-Oct-23	12-Jan-25
MHI Procurement Interface	405	28-Dec-24	02-Aug-26
06. Pond	238	05-Apr-24	19-Mar-25
Pond - Civil	238	05-Apr-24	19-Mar-25
07. Underground	408	09-Nov-23	31-Jul-25
UG - Civil	392	09-Nov-23	08-Jul-25
UG - Electrical	35	13-Jun-24	07-Aug-24
UG - Concrete	236	02-Aug-24	31-Jul-25
UG - Piping	206	06-Aug-24	17-Jun-25
08. Aboveground	512	02-Jan-25	01-Feb-27
AG - Steel	384	02-Jan-25	04-Aug-26
AG - Mechanical	427	23-Jan-25	27-Oct-26
AG - Piping	345	04-Jun-25	30-Oct-26
AG - Electrical	392	02-Jul-25	01-Feb-27
09. Start Up / Commissioning	277	09-Mar-26	31-Mar-27
Start Up / Commissioning	277	09-Mar-26	31-Mar-27

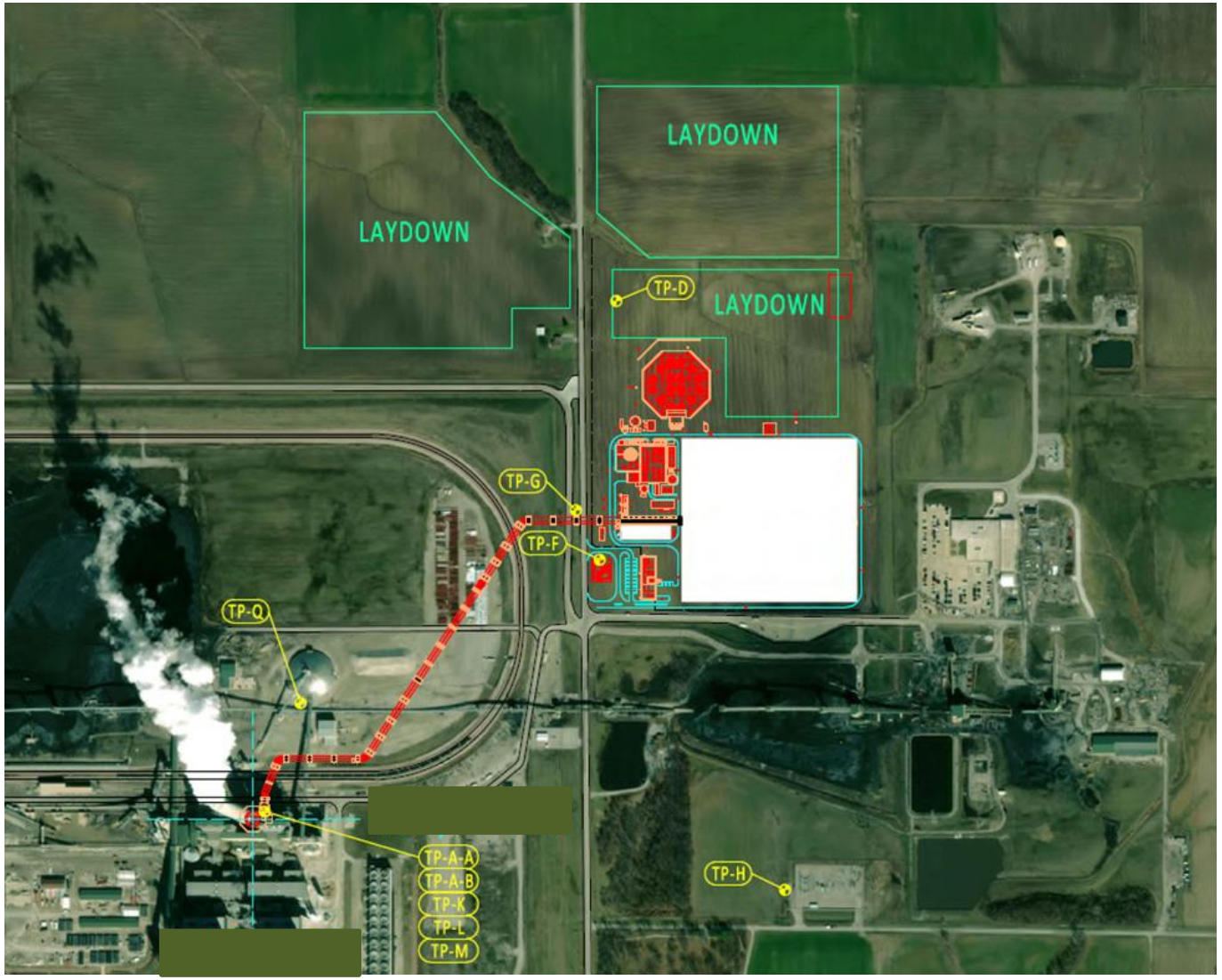


Kiewit · MITSUBISHI HEAVY INDUSTRIES AMERICA · ILLINOIS Prairie Research Institute · PRAIRIE STATE Generating Company · NETL NATIONAL ENERGY TECHNOLOGY LABORATORY · U.S. DEPARTMENT OF ENERGY

Carbon Capture Location

Kiewit · Mitsubishi Heavy Industries America · Illinois Prairie Research Institute · Prairie State Generating Company · National Energy Technology Laboratory · U.S. Department of Energy

Carbon Capture Facility



Kiewit · Mitsubishi Heavy Industries America · Illinois Prairie Research Institute · Prairie State Generating Company · National Energy Technology Laboratory · U.S. Department of Energy

ISBL Detailed Engineering

- Break from slideshow to review:
  - Block Flow Diagram (BFD)
  - ISBL Plot Plan
  - Process Flow Diagram (PFD)

OSBL Detailed Engineering

- Break to review 3D model

Review of Overall Plant Performance

- Output
  - 8,462,000 ston annually of CO2
  - 95% Capture
- Power Consumption: ~85.5MW

Results and Closing Discussions

- Project not currently economic without additional enhancements to federal tax credits
- PSGC Owners may consider a partnership with a third-party developer/owner
- Third-party developer would need to secure funding and necessary permits

Acknowledgements

Name	Organization
Andrew Jones, Carl Laird	National Energy Technology Laboratory / US Department of Energy
Don Gaston, Javier Arzola, Rich Meyer	Prairie State Generating Company
Kevin O'Brien, Yongqi Lu, Vinod Patel, Stephanie Brownstein, Jason (Zhenxing) Zhang, Jason Dietsch	Prairie Research Institute / University of Illinois Urbana-Champaign
Tim Thomas, Tiffany Wu, Cole Maas	MHIA
Keisuke Iwakura, Shintaro Kiuchi	MHIENG
Matt Thomas, Alan Donovan, Bob Slettehaugh, Bryan Lofgreen	Kiewit Engineering Group
Paula Guletsky, Anthony Baker	Sargent & Lundy

This project is supported by the U.S. Department of Energy / National Energy Technology Laboratory (DOE/NETL) through Cooperative Agreement No. DE-FE0031841

Kiewit MITSUBISHI HEAVY INDUSTRIES AMERICA ILLINOIS Prairie Research Institute PRAIRIE STATE Generating Company NATIONAL ENERGY TECHNOLOGY LABORATORY U.S. DEPARTMENT OF ENERGY